

CS15210: Waves and Signals

Helen Miles (hem23@aber.ac.uk)

25/01/16

(based on slides by Mike Clarke)

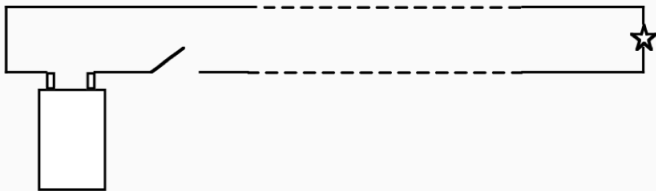
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3. Waves: Basic Anatomy
4. Wrapping Up

- Signals and waves
- Different types of transmission
- Transmission media
- Voice telephony
- Data transmission and data networks
- How much, how fast, and how far?

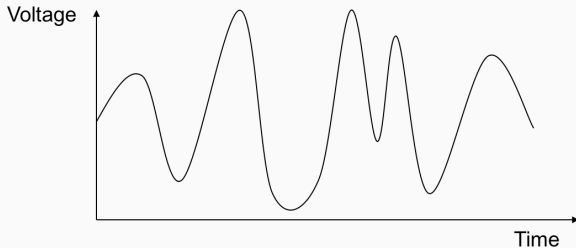
Simple telegraphy (1840s)



- Components: battery, switch, sensor
- Data transmission: sent by switch, read by sensor
- Current systems have evolved from this simple idea:
 - A transmitter (Tx) and a receiver (Rx)

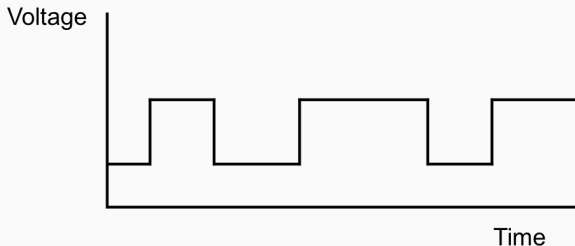
- Signals are sent as varying voltage over time
- Signals can be analogue or digital
 - Analogue signals vary continuously and can take any value within some given range
 - Digital signals are chosen from a discrete range of possibilities

Analogue Signal



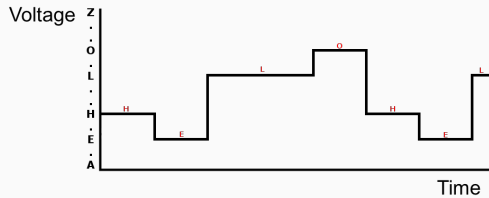
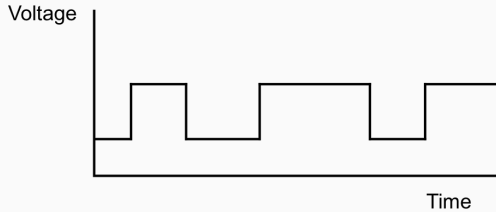
Analogue signals vary continuously
and can take **any** value within some given range

Digital Signal



Digital signals are chosen
from a **discrete (limited, finite)** range of possibilities

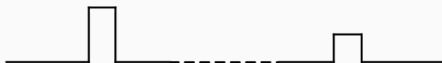
Digital Signal



e.g. $\{0, 1\}$, $\{\text{long}, \text{short}\}$, or $\{\text{A-Z}, 0-9\}$

How Signals get Damaged

attenuation



dispersion



distortion



Signals may become damaged, or experience interference...

How Signals get Damaged: Attenuation

attenuation



Change in voltage means values could be read incorrectly

How Signals get Damaged: Dispersion

dispersion



Signals get stretched out, incorrect timing,
particularly important for time-based reading

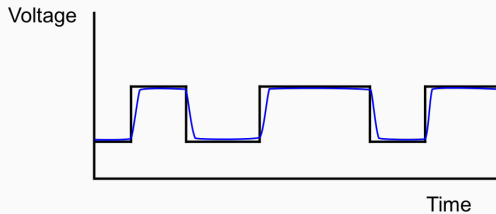
How Signals get Damaged: Distortion

distortion



A mix of attenuation and dispersion that leads to
an unintelligible signal

Rise and Fall Time

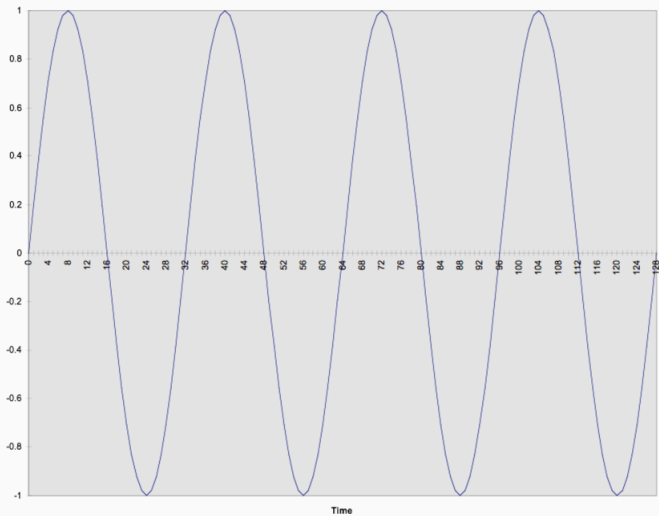


It takes (a tiny amount of) time to change voltage...

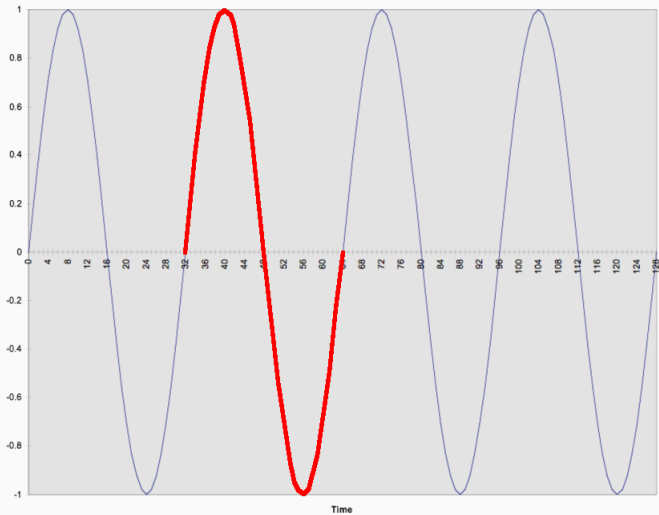
The signal contains some distortion already,
computer systems must deal with this

- Data can be analogue or digital, independent from the signal
- E.g. speech is analogue data, text is digital data
- Digital data *can* be transmitted using analogue signals and vice-versa
 - analogue-to-digital converters (ADC)
 - digital-to-analogue converters (DAC)

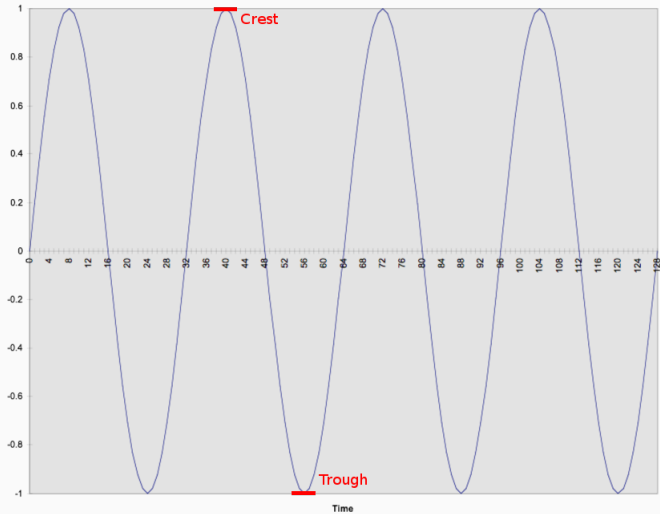
Waves



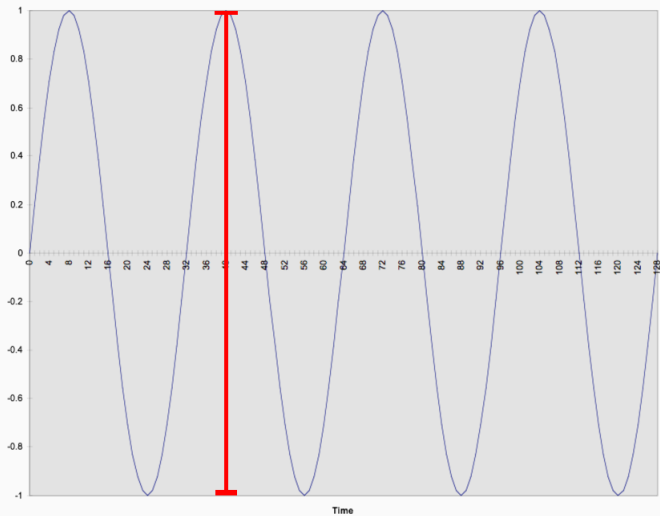
Waves: A cycle



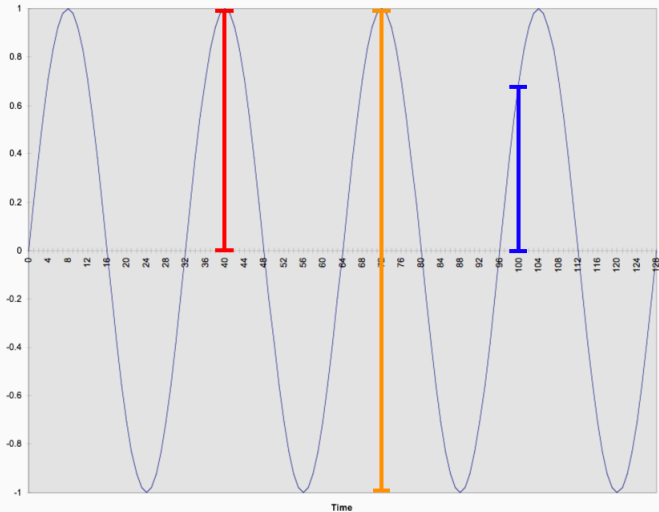
Waves: Crest and Trough



Waves: Peak-to-Peak Voltage (V_{PP})

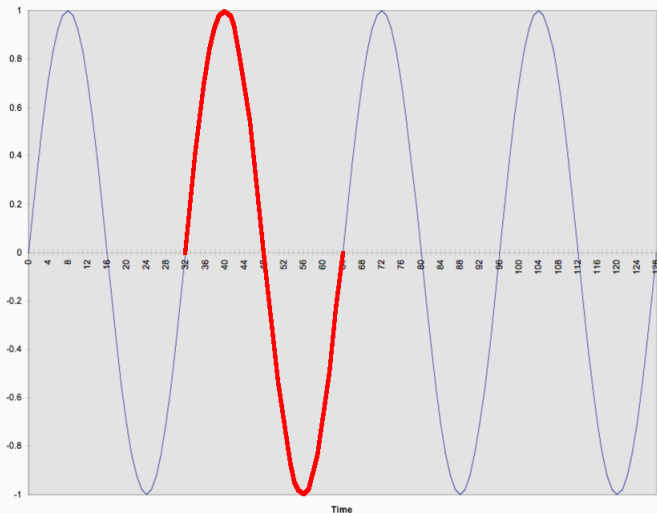


Waves: Amplitude



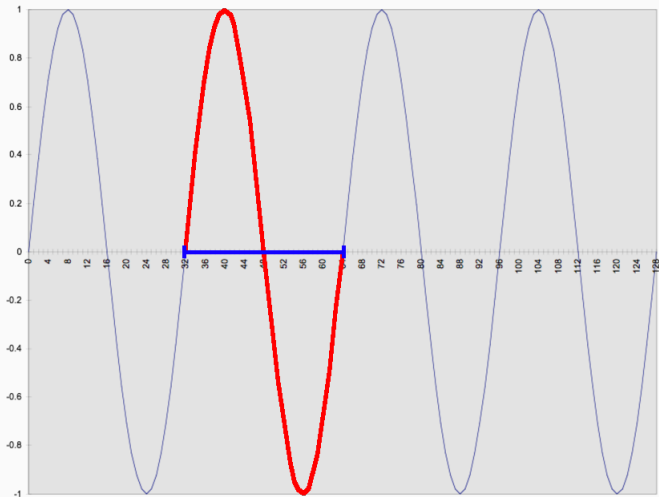
(Peak) amplitude, peak-to-peak amplitude, instantaneous amplitude

Waves: Frequency



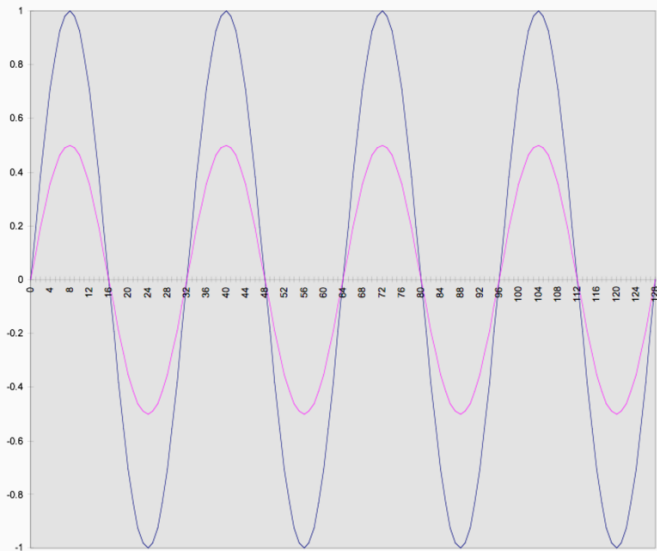
Number of complete cycles per second, measured in Hertz (Hz)
i.e. if a cycle takes 1 second, frequency = 1 Hz

Waves: Wavelength



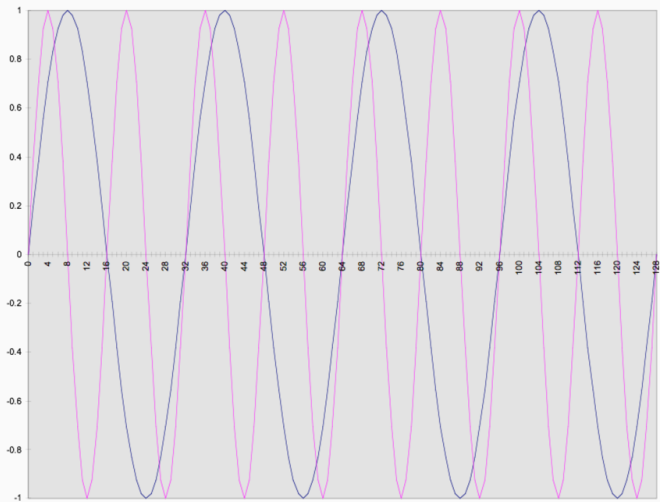
Length of a cycle **in metres**, symbol lambda λ

Amplitude difference



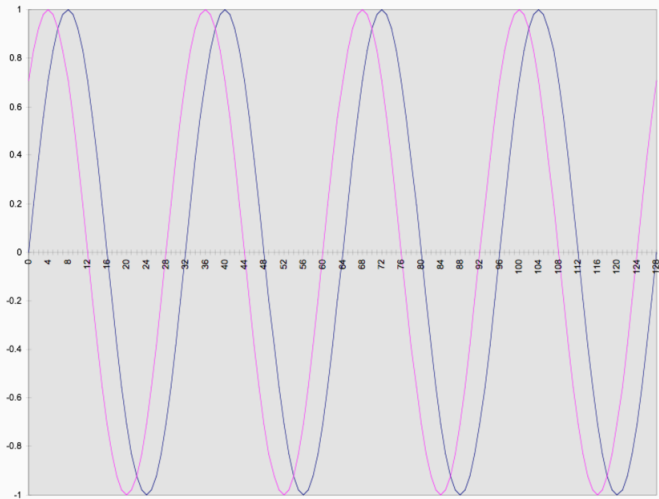
Two waves, the only difference is the amplitude

Frequency difference



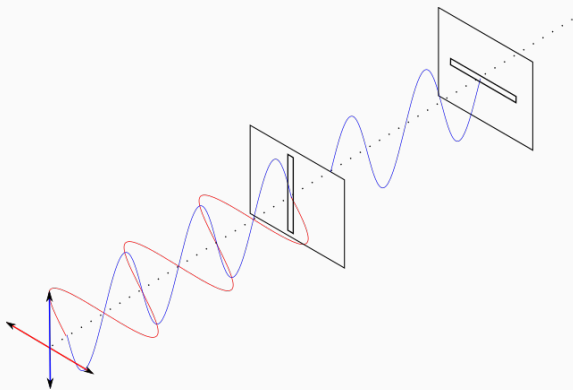
Two waves, the only difference is the frequency

Phase difference



Two waves, the only difference is the start time of the cycle

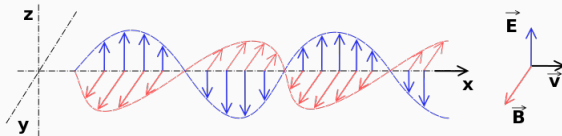
Polarisation



Waves can oscillate at different orientations

Polarisation filters can block waves that travel at different orientations

The Electromagnetic Wave



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Though we don't ask you in this course to understand the physics behind the electromagnetic wave, you may like to look at this:

http://missionscience.nasa.gov/ems/02_anatomy.html

The important things to remember:

- Signals are sent as varying voltage over time
- How signals become damaged:
 - attenuation, dispersion, distortion
- Signals and data can be analogue or digital
 - Can send either kind of data as either kind of signal using converters (ADC, DAC)
- Anatomy of a wave:
 - cycle, amplitude, wavelength, frequency
- How two waves can be compared:
 - amplitude, frequency, phase

More on Waves and Signals!
9am, Friday 29/01/15, HO-A12